

Adversary Behavioral Modeling: Emerging Tools to Support the Analyst

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 - Social Network Analysis
 - Bayesian Networks
 - Command and Control
- The Real Challenge

Objectives of Workshop



- *To present to the Air University community tools that have been developed through Air Force funding (AFOSR and AFRL) that can support behavioral analysis of adversaries*
 - *The tools have reached some level of maturity (beta) and have been*
 - *used by the developers to support a variety of projects*
 - *tried out by others*
- *To encourage their use in individual and team projects. This would accomplish the following:*
 - *Enhance the analytical/computational parts of the projects*
 - *Provide feedback to the developers regarding desired capabilities, interface improvements, supporting materials*
 - *Create a set of case studies that can be used in the education and training of analysts and serve as the basis for further development*

Objectives of Behavioral Analysis Modeling



- *To relate an adversary's behavior to social and cultural attributes*
- *To relate an adversary's organizational structure to behavior, when both structure and behavior are conditioned by cultural and social attributes*
- *To provide tools that will support Course of Action development and assessment that are effects based*
- *To identify through the models the points of influence that have the potential to modify the behavior of individuals and organizations*
- *To facilitate the development of COAs that include coordinated kinetic and non-kinetic actions*
- *To explore, through a computational modeling framework, the nexus between data and models for individual adversaries (micro level) and data and models for organizations of adversaries (macro level).*

The Agenda



- The first module contains several approaches to Social Network Analysis by leading researchers in two universities
- Prof. Kathleen Carley from Carnegie Mellon University and her students have developed a suite of tools that has as its centerpiece Social Network Analysis, but does much more than that. The tools are being used by a variety of organizations in DoD, the Intelligence Community, and other organizations.
- Prof. Dick Deckro from the Air Force Institute of Technology (AFIT) has been conducting research on SNA as well as applying the methodology to operational problems since the late 90s.
- In SNA nodes represent entities (individuals or organizations) and lines represent the existence of a binary relationship between these nodes. The nodes and the existence of the lines that connect them are extracted from data. The choice of metrics yields different insights in the relationships.

The Agenda



- The second module presents a very different way of modeling. Bayesian networks have existed for a long time.
- Advances in computation (both in hardware and in algorithms) have enabled their use for non-trivial problems
- A second problem is the amount and type of data that they require.
- Early approaches to address both issues (e.g., SIAM, CAESAR/EB) made approximations that were not always justifiable
- Recent theoretical and algorithmic developments in Influence Nets, a variant of Bayesian Nets, have established a rigorous foundation for extending the models to address temporal issues (Timed Influence Nets)
- First Dr Lemmer from AFRL/IF will present JCAT, a Bayesian net tool that he developed over the last ten years; it is being used by several DoD organizations
- Dr Wagenhals from George Mason University will present Pythia, an Influence net tool that started as an extension of SIAM (1994) to address time. Pythia has been a testbed for research and has evolved as a tool over the years.

The Agenda



- In Pythia, time is handled through the use of Temporal Logic. The temporal engine has been used in self-standing tool, Temper, that has found some very interesting applications in its own right.
- The third module contains two different models:
 - The first by Dr. Santos from Dartmouth College addresses the difficult problem of capturing an adversary's intent and folding it in behavioral analysis
 - The second, CAESAR III, is a tool for the design and evaluation of command organizations. Recently, the tool has been enhanced to include cultural attributes – whether they influence an adversary's organization and its behavior or affect the way a coalition organization should be designed.
- The session ends with all the presenters forming a panel to address questions from the workshop participants.
- On Friday, there will be live demonstrations and participants will have the opportunity to discuss individual tools and their potential applicability to their work/projects.

The Challenge

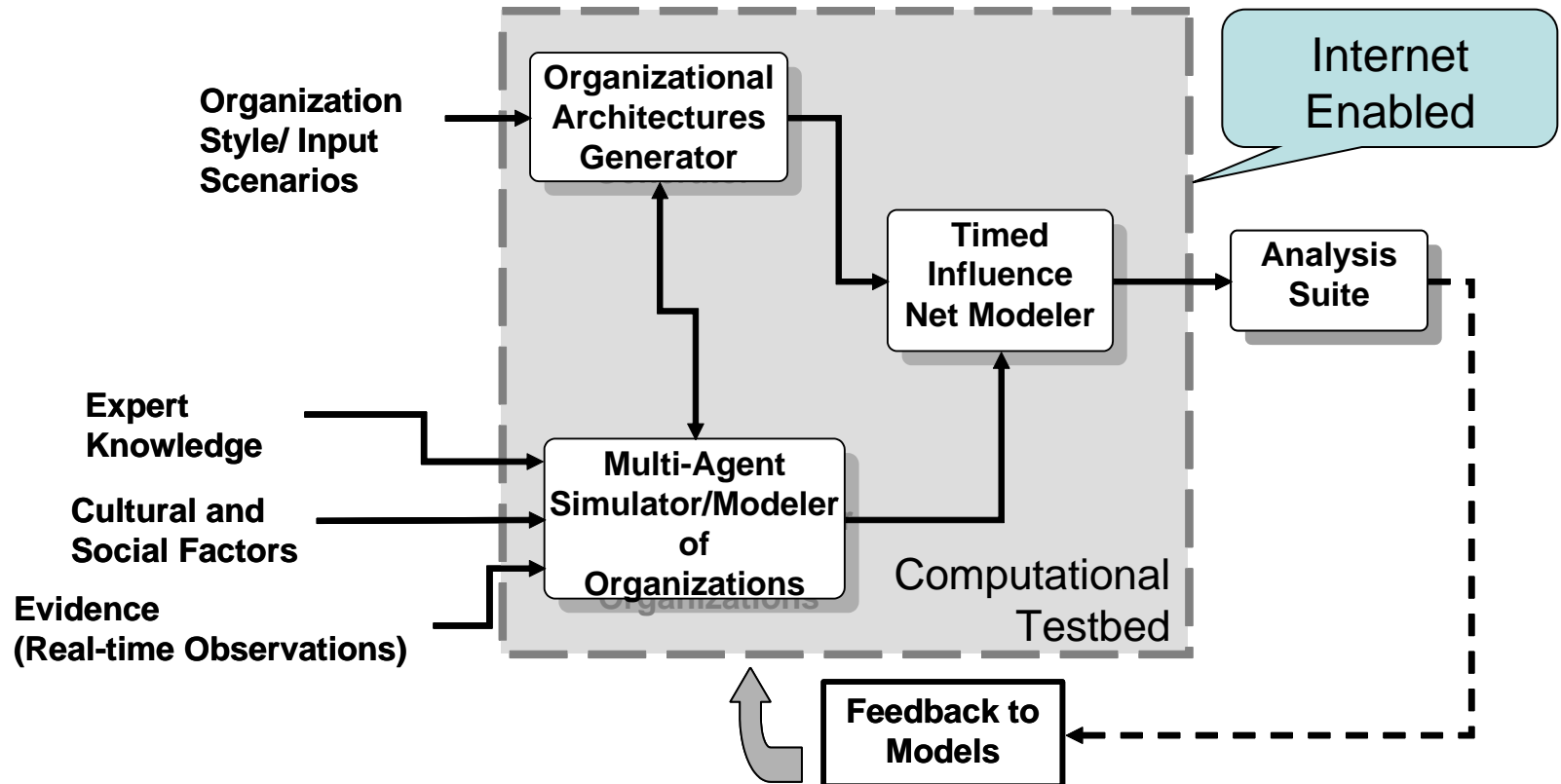


- What has been described is a set of tools that, while they have different theoretical and methodological foundations, can contribute to behavioral analysis of adversaries
- Their existence, however, poses a meta-problem:
 - How can these tools be used by an analyst in a coordinated way to enhance the analysis?
 - Even when two or more tools use the same data, they use it in different ways and extract different meaning from it; can their results be re-integrated?
 - A key example is the concurrent use of SNA and Bayesian networks – the former is based what is colloquially known as the frequentist approach while the latter is based more on the internalizing of stories by the modeler or analyst who then assigns influence strengths to between events.
 - This is a fundamental problem that goes beyond the ability to “pass data” between models

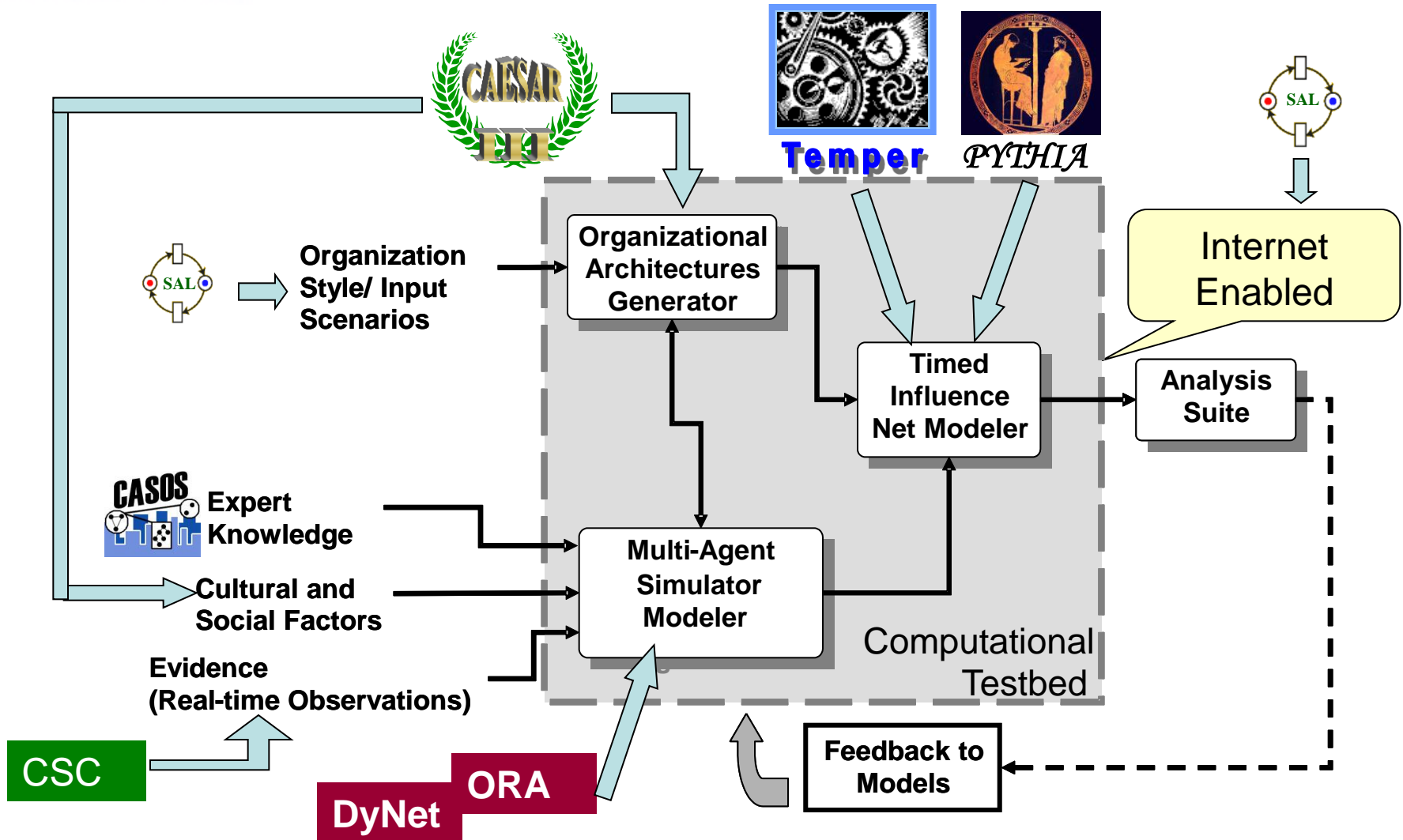
An Approach



- An AFOSR sponsored Multidisciplinary Research Initiative is focused on addressing this meta-problem by implementing a distributed (internet enabled) computational testbed consisting of a set of models and tools developed independently by three collaborating research centers.

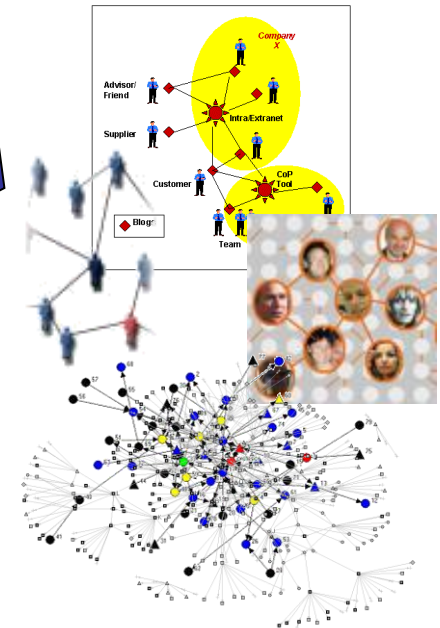
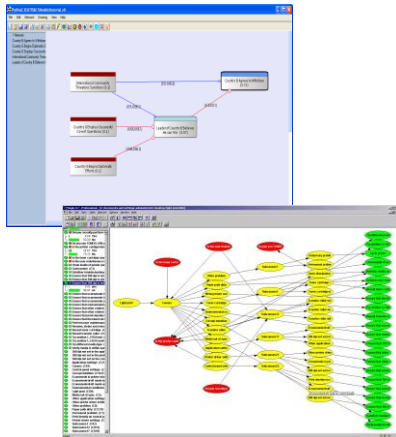
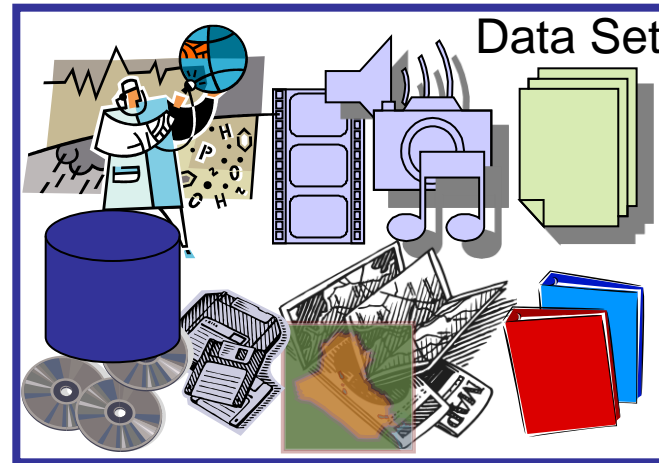


Models and Status



Modeling with Multiple Approaches

Posing the Meta-Problem



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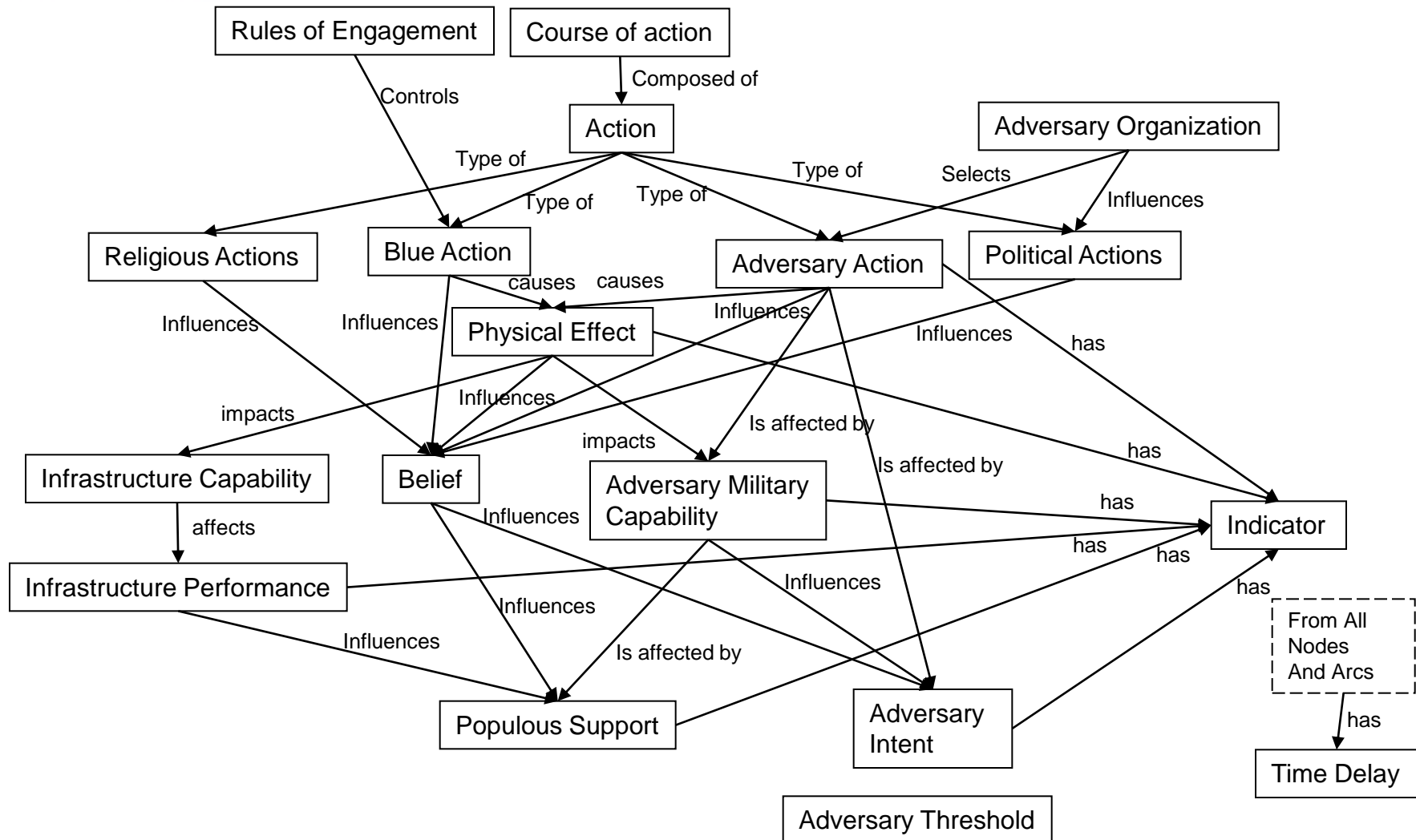
Model Views

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- **Data Set to Models**
 - Parsing and partitioning of data set into machine readable knowledge items/sub-sets each producing a computable model view
 - Machine translation
 - Ontology Learning and Engineering
 - Computer aided model generation/construction
- **Models to Models**
 - Solving *some* problem with each model contributing a part to/of the solution
 - Inter-model consistency
 - Inter-model refinement
- **Models to Data Set**
 - Given $M = \{m_1, m_2, \dots, m_n\}$, where m_i 's are model views extracted from a common data set
 - Checking if the data set is consistent
 - Identifying need for more information
 - Knowing when enough *dots* are available and *connected* to start inference

- **Models**
 - Adversarial Networks (social, knowledge, task networks)
 - Timed Influence Nets (TIN)
 - Concept Maps for model definitions and representation
- Data set to Adversarial Networks – **AutoMap**
- Data set to Timed Influence Nets – work in progress at both **CASOS** and **SAL**

- **Develop a generalized model that relates concepts of adversary and the beliefs, actions, attitudes, indicators, etc. of the adversary and the local population that may support that adversary to potential actions of Blue and other Actors**
 - **Use the Concept Map technique**
 - **Collaborative Development to capture multi disciplinary points of view**
 - **Formalize the Concept Maps to construct domain and model ontologies**
- **Map the elements of the concept map to elements in Influence Net**
- **Define the types of analysis and questions that may be answered by the systems, procedures, and techniques currently in use**
- **Run the analyses**
- **Store the domain and model ontologies for future use**



- Modeling of an adversary's reactive, emergent behavior requires employment of a wide range of representational and computational approaches to construct a holistic view of the domain
 - Individual approaches have been successfully shown to capture a or *some* aspect of the domain, e.g.,
 - Social Network Analysis – social, organization, and task nets
 - EBO modeling, planning, and evaluation – Probabilistic, (Timed) Influence Nets, Bayesian Nets
 - Adversary Force Structure Simulation – Discrete Event Systems (Colored Petri Nets)
 - Etc.
 - There is, however, very little on integrating the multiple approaches into a single framework to address the *combined effect*
 - Note, the idea here is not to integrate technologies. For example, the issue is not how Influence Nets can be employed to conduct a Social Network specific analysis and/or vice versa

- Given that we have *already* constructed different models, e.g., Adversarial Networks, Influence Nets, Time Graphs, etc., from a shared data set using the available tools, and run the analyses, on the models, supported by these tools,
 - What *connections* or *translations* exist among the outputs of these analyses?
 - What *query* can be generated in one model that can be answered by the other?
 - What are the *overlaps* among the models?
 - How do we determine if the output of one is *supported* by the output of the other?
 - How do we identify *gaps*, *inconsistencies*, or *incompleteness* (need for more information)?
 - ...

- The work you are seeing today started as basic research in the mid-90s
- It has taken 10+ years :
 - To bring the tools to a reasonable level of maturity and usefulness and for the researchers to start understanding the users' needs
 - For the users to start requiring tools to support their efforts
 - For transitioning to begin
- If past history is an indicator, then we should expect the descendants of these tools to be part of any analyst's toolkit in 2015
- **Let's get started!**